Optimization of Non-Contrast Renal MRA using a TI-Prep scan for Time-Spatial Labeling Pulse (time-SLIP) in 3D balanced SSFP

J. Takahashi[1], Y. Tsuji[1], Y. Hamada[1], T. Yoshida[1], S. Isono[2], A. Ninomiya[2], Y. Kassai[3], and M. Miyazaki[3,4]

[1]Toranomon Hospital, Tokyo, Japan, [2]Toshiba Medical Systems, Tokyo, Japan, [3]Toshiba Medical Systems Corp., Otawara, Tochigi, Japan, [4]MR, Toshiba Medical Research Institute USA, Vernon Hills, Illinois, United States

PURPOSE

Due to the recent association of gadolinium contrast agents and Nephrogenic Systemic Fibrosis (NSF) disease, there have been increasing interests in using non-contrast MRA techniques as an alternative. Based on arterial spin labeling (ASL) techniques, mainly two types of techniques are reported for the depiction of renal arteries, one with navigator echoes and the other one with respiratory gating [1,2]. The navigator technique uses a short inversion time to acquire within a cardiac cycle, whereas the respiratory technique applies a longer black blood inversion time (BBTI) so the marked blood travels further in distance. The respiratory gated ASL technique, called time-spatial labeling inversion pulse (time-SLIP) with 3D balanced SSFP, can be optimized to have the best contrast between renal arteries vs. cortex/medulla at the BBTI of around 1100 ms in volunteers. However, the depiction of the smaller renal branches was found to be dependent of the flow speed in patients, especially with those with slow flow. In this study, we will correlate the 2D BBTI prep scans, which provides a series of single shot scans with varying BBTI times, with the 3D balanced SSFP images.

MATERIALS and METHODS

The time-SLIP pulse was placed to mark the aorta, which flows directly into the renal arteries, in addition to nulling the background signals. For suppression of venous flow, an inferior sat-band pulse was applied. In order to acquire data in a relatively short scan time, only a tag-on pulse was used with respiratory gating and parallel imaging. To find an appropriate BBTI time, the 2D BBTI prep-scan was applied prior to the 3D scan. All experiments were performed on 8 healthy volunteers and 4 consecutive patients using a clinical 1.5-T system (Toshiba, Excelart Vantage), equipped with a parallel imaging torso coil. Typical acquisition parameters for the 2D BBTI prep-scan were as follows; TR/TE=4.4/2.2 ms, FA= 90 deg., matrix=256x256, 10-mm section slice, respiratory triggering, parallel reduction factor=2.0, time-SLIP slice thickness=180 mm, BBTI=1100, 1300, 1500, 1700, and 1900 ms, 2 segmentations, fat suppression, and a total scan time of about 60 sec, depending upon the respiratory cycle. The 3D acquisition parameters were as follows; TR/TE=4.4/2.2 ms, FA= 120 deg., matrix=256x256 (interpolated to 512x512), thirty 3-mm section slices (interpolated to sixty 1.5-mm slices), resolution of 0.6x0.55/1.5 mm after interpolation, respiratory triggering, parallel reduction factor=2.0, time-SLIP slice thickness=180 mm, 2 segmentations, fat suppression, and a total scan time of 3 to 5 min, depending upon the respiratory cycle.

RESULTS

Figure 1 shows a contrast ratio between blood (aorta and renal artery) and background (cortex and medulla) signals at various BBTI times, obtained on healthy volunteer. Figure 2 a) shows result images of the 2D BBTI prep-scan. After selecting the BBTI of 1300 msec from the 2D BBTI prep-scan images, 3D imaging was performed using the same BBTI, 3D image after maximum intensity projection (MIP) is shown in Fig. 2b). Figure 3a) shows the result images of the 2D BBTI prep-scan images and Fig. 3b) the 3D image after (MIP) obtained using the selected BBTI of 1300ms from the prep-scan on a 68 year old female patient with a dissecting aortic aneurism. Good correlation was obtained between the 2D BBTI prep-scan and 3D images in both volunteers and patients.

DISCUSSION

The 2D BBTI prep-scan presents various BBTI images, allowing one to select an appropriate BBTI prior to the 3D scan. In order to have the same effect in marking or tagging the region of vessels, the time-SLIP slice thickness in the 2D BBTI prep-scan was selected to be the same as that of 3D scan. The scan time of the 2D BBTI prep-scan is about 60 sec. For normal volunteers, there is a tendency to have good image quality in 3D images using the BBTI of 1100 msec, which is from the contrast ratio between blood and renal background. However, in some cases, it was difficult to estimate how far the blood flow can reach in elder patients with very slow arterial blood flow. In these cases, the 2D BBTI prep-scan was very useful. From the prep-scan, BBTI times of 1500 to 1900 msec were often selected to give quality 3D images.
In conclusion, the 2D BBTI prep-scan provides a fast estimation of BBTI prior to acquisition of 3D images. The correlation of 2D BBTI prep-scan and 3D images were matched in both volunteers and patients.

REFERENCES:
1] Spuentrup E, et al, Radiology 225(2):589-596, 2002.
2] Takahashi J, et al, ISMRM p179, 2007.

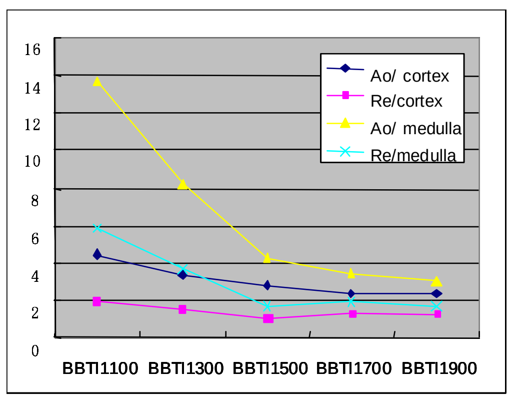

Fig. 1 Contrast ratio between bloods vs. background signals at various BBTI times.

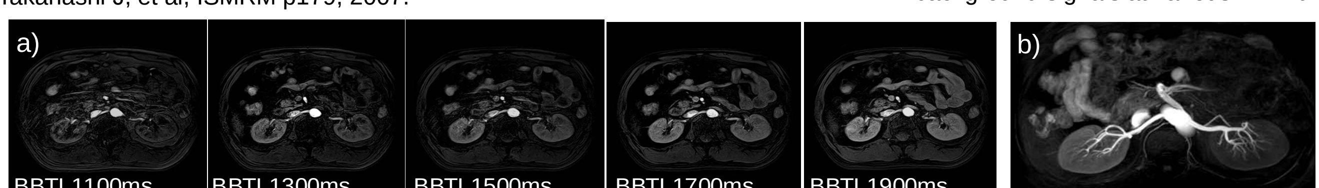

Fig. 2a) Various BBTI time images obtained on a volunteer using the 2D BBTI prep-scan. b) BBTI of 1300 msec was selected to give good image quality in a 3D MIP image.

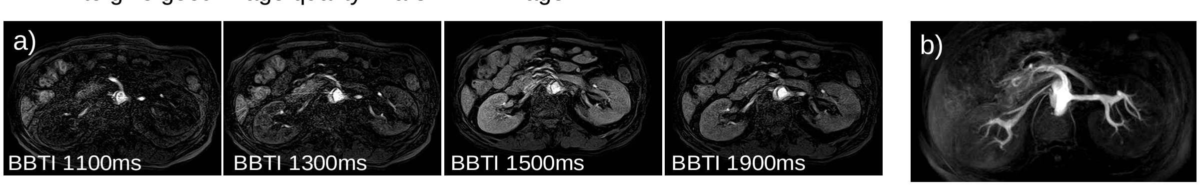

Fig. 3a) Various BBTI time images obtained on a 67 year-old patients with dissecting aneurysm using the 2D BBTI prep-scan. b) BBTI of 1300 msec was selected to give good image quality in a 3D MIP image.